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THE PANAMA CANAL[1]

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The ancient world wonders, recorded in the history of man, mark achievements of engineering science. With the progress of civilization, the production of great works increased until the period of wonders apparently ceased. Engineering of to-day has assumed such enormous proportions of worldly activities, that it may well be said we are living in an age characterized by the continuous performance of wonders.

Nationally, economically and commercially the Panama Canal commands the attention of the world to-day as the vastest engineering undertaking in all history.

More than most great national undertakings, its chief purpose is for the general good of the American people and incidentally offers some advantages to nearly all the nations on the earth.

Isthmian Canal History

The Isthmus of Darien was discovered by Columbus in 1502 and the province of Darien known as Castilla del Oro, under Vasco Nunez de Balboa as govenror, was founded soon after.

Balboa, in Sept. 1513, crossed the isthmus with a considerable force of Spaniards and Indians and discovered the Pacific Ocean which he called the South Sea. Through the efforts of his enemies Balboa was soon superseded as governor of the Province by Pedro Arias de Avila, known as Pedrarias.

In 1517, Balboa was charged with treasonable conduct by Pedrarias and, after the form of a trial, was condemned and beheaded. "Thus closed the career of the brave and unfortunate man who first marked out a line of transit across the Isthmus."

The old City of Panama on the Pacific coast, was settled in 1517 and the Atlantic port Nombre de Dios, 40 miles east of the present City of Colon, was founded in 1519. Between 1517 and 1520 a trans-Isthmian route was established via the royal road to

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[1] Read before the University of Toronto Engineering Society, Feb. 12, 1913.

Cruces, from old Panama to Cruces on the Chagres River, using the river as a water route from Cruces to the Atlantic and thence to Nombre de Dios.

In 1597 the Atlantic port was moved westward to Puerto Bello, 21 miles east from the present City of Colon. Also a new road was built from Panama due north to Puerto Bello, which is still in existence.

During the century, the Isthmian commerce grew to such importance that it became the toll gate between Western Europe and Eastern Asia.

As early as 1520, Charles V. of Spain is said to have directed that a survey should be made to determine the feasibility of a canal across the Isthmus at Panama. "The governor, Pascual Andagoya, reported in 1534, that such a work was impracticable and that no king, however powerful he might be, was capable of forming a junction of the two seas or of furnishing the means for carrying out such an undertaking."

Old Pamana became a centre of wealth, and considerable trade was established with the Pacific coast of Central and South America.

Though well fortified, the city was sacked and burned by Morgan in February, 1671, and in 1673 the present city was founded six miles west from the original site.

In January, 1522, Gil Gonzales with one hundred men, explored the Pacific coast northward from Panama and landed in the Gulf of Fonseca, about 650 miles from Panama. He discovered an inhabited country under a chief called Nicarao, and found what he considered a great inland sea which he afterward named Lake Nicaragua.

Thus a maritime trade of some importance was established between Spain and Lake Nicaragua which reached its greatest activity near the end of the sixteenth century.

Although the feasibility of a canal across Nicaragua was recognized soon after the route was discovered, there is no evidence of any investigation having been made until 1779 under instructions of Charles III. of Spain.

In 1781, Galisteo reported that Lake Nicaragua was 134 feet above the Pacific Ocean and that high mountains intervened between the two bodies of water, making a canal impracticable. However, a company was subsequently formed to build such a canal but nothing further was ever done.

The English Capt. Nelson, in 1780, captured Fort San Juan but was forced to return to Jamaica without accomplishing any permanent results.

Panama achieved her independence from Spain in 1819. Later she became a member of the Granadian Confederacy and then joined the United States of Columbia.

During the three hundred years of Spanish occupation no actual progress was made toward establishing an Isthmian communication between the seas.

As a result of the extensive travels and accounts of Baron von Humboldt a new interest was revived among the nations of the world, and subsequently Spain, in 1814, passed a formal decree for the construction of an Isthmian Canal.

However, this never resulted in any actual work, for in 1823 Spain lost the last of her Central and South American provinces by secession.

Mr. John Baily made a survey of the Nicaragua route for an English Company in 1826 but, failing in his main purpose, he remained in Central America until President Morazin, in 1837, employed him to determine the best location for a canal.

President Bolivar of Panama in 1827, commissioned Mr. J. A. Lloyd to survey the Isthmus of Panama with a view to locating a transport line either by road or canal.

The republic of New Granada, in 1838, granted a concession to a French company, authorizing the construction of a road, railroad or canal with one terminus at Panama. After several years spent by this company in exploration, the French government was drawn into the matter and in 1843 a rather complete investigation and report was made favoring a ship canal closely approaching the present Panama route at a cost of twenty-five million dollars.

About the middle of the nineteenth century a succession of great events vastly increased the importance to the United States of a maritime connection at the Isthmus. The history now takes on such a broad aspect that it is beyond the limitations of this paper to give more than the few important incidents leading up to the present situation.

After a series of complications the American Atlantic and Pacific Ship Canal Co. in 1850, appointed Col. O. W. Childs, as Chief Engineer, to make a careful survey of the Nicaraguan route which he completed in 1852. A provisional route of stage and boat was established and used for several years but as no progress was made on the canal construction, the Nicaraguan government annulled the contracts made with the company and seized the latter's property.

The French Panama Company, in 1847, secured the exclusive privilege of building a railroad across the Isthmus, which road was completed in 1855.

General Grant in his first message to Congress, in 1869, "commended an American Canal on American soil, to the American people."

Congress promptly responded to this sentiment and accordingly authorized the President to appoint an Interoceanic Canal Commission to investigate the subject. Surveys of the Tehuantepec, Nicaragua and Panama routes were made between 1870 and 1875 and in its final report 1879, this commission favored the Nicaragua route.

The men who made these surveys were Captain R. W. Shufeldt, U. S. N., Com. A. F. Grosman, U. S. N., who lost his life on the work, Also Com. Chester Hatfield, U. S. N., Mr. A. G. Menocal, and Capt. Edw. P. Lull, U. S. A.

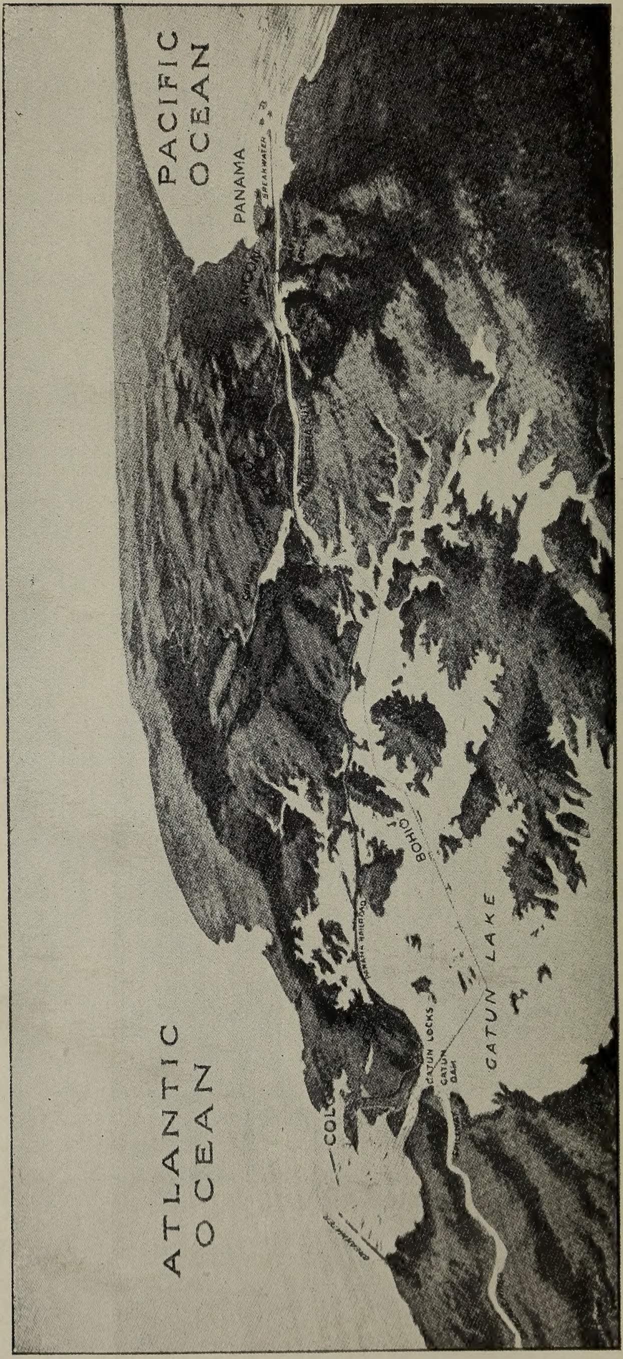

Fig. 1—Bird's-Eye View, Panama Canal, Lock Level Project

While the United States Government was engaged in makin these surveys and before any arrangement for a canal was completed, a provisional company was organized in France to investigate the feasibility of an Isthmian Canal. In May, 1876, Lieut. L. N. B. Wyse, as representative for this company, entered into contract with the Colombian Government by which, under a later modification, the Company obtained exclusive privileges for 99 years, for building a canal, the general route of which was to be determined by an international congress.

Such a congress met in 1879 and decided on a route which is practically the one now being built. F. de Lesseps, in 1881, formed the Panama Canal Co., which bought up the concessions obtained by Wyse, and proceeded to construct a canal between Panama and Colon.

This canal was to be of the sea level type, 72 ft. wide at the bottom, 29.5 ft. deep, 47 miles long and to cost $169,000,000.

The plan was soon changed to a lock canal and after expending $260,000,000, obtained from the sale of shares in France and finally by lottery, the work was abandoned, in 1889, for want of funds. A new Panama Canal Co. was formed in France, in 1894, with a ten year concession, which was afterward extended to 1910.

About twelve miles of canal was completed at the Atlantic end and some considerable excavating done in the Culebra cut amounting in all to about seventy-seven million cubic yards and costing about $267,000,000.

The new company continued work, between 1895 and the time the United States took possession, with a force of between 2000 and 3600 men.

During this time about five million cubic yards were excavated at a cost of about $7,000,000, which amounts are already included in the above.

The financial entanglement and exposures of fraud prevented the company from raising further funds though work was continued in a provisional manner.

In 1885 the Nicaragua route was again surveyed by Mr. A. G. Menocal after a treaty had been negotiated between the United States and Nicaragua, in 1884, to build a canal involving joint ownership by the two nations. Nothing came of this treaty as it was withdrawn by Nicaragua.

In 1887, Mr. Menocal and others were granted a concession from Nicaragua to construct a canal between Greytown and Brito. This gave rise to the formation of the Maritime Canal Co. of Nicaragua incorporated by Congress in 1889.

This Company had a sad fate and after the expenditure of considerable money, the Nicaraguan Government declared the contract forfeited.

Several bills were brought before Congress with a view of seeking governmental aid.

While such a bill was under consideration in 1895, an amendment to the Sundry Civil Appropriation bill was passed, by which a Nicaragua Canal Board was created to ascertain the feasibility and cost of completing the canal.

On this board were appointed Lieut. Col. Wm. Ludlow, Admiral Mordecai T. Endicott, U. S. N. and Mr. Alfred Noble. The investigation was made and a report submitted, setting forth the impossibility of properly concluding the work with the limited time and means allotted.

Accordingly the President, in 1897, was authorized to appoint a new board to continue this work. The second board consisted of Rear Admiral John G. Walker, Col. Peter C. Hains and Prof. L. M. Haupt. This body, known as the Nicaragua Canal Commission, submitted its report in 1899, and this indicated the desirability of a more general investigation with a view of examining all feasible routes across the Isthmus.

The Isthmian Canal Commission was thus created by Congress in 1899, and the President appointed the following members to this Commission: Rear Admiral J. G. Walker; Hon. Samuel Pasco; Mr. Geo. S. Morison; Mr. Alfred Noble; Lieut. Col. O. H. Ernst; Col. Peter C. Hains; Prof. L. M. Haupt; Prof. Wm. H. Burr; Prof. Emory R. Johnson; Lieut. Com. Sidney A. Staunton, Secy.

This Commission made a very complete investigation of all feasible routes of the entire Isthmus and in an exhaustive report, submitted to the President in 1901, presented their findings for nineteen different routes, four of which were particularly investigated by the Commission as offering the most advantageous conditions, and of these the Panama route was selected as being the most favorable.

As a result of the recommendations of this commission Congress passed an act, dated June 28, 1902, authorizing the President to acquire, at a cost not exceeding $40,000,000, the rights, franchises and property of every kind belonging to the New Panama Canal Company, including its shares of the Panama Railroad Company, provided a satisfactory title could be obtained. This same act contained other instructions relating to property rights to be acquired from the Republic of Colombia and directed the President to cause to be constructed a ship canal from the Caribbean Sea to the Pacific Ocean.

On January 22, 1903, Colombia proposed a treaty offering to lease the necessary canal land to the United States for 100 years. The following August Colombia rejected this treaty and on November 4th, Panama asserted her independence from Colombia, being almost immediately recognized by the U. S. and European powers.

On February 23, 1904, a canal treaty between the U. S. and Panama was signed by which Panama granted in perpetuity, a zone five miles wide on each side of the canal route, with exclusive police, judicial, sanitary and other control within this zone excepting the terminal cities of Colon and Panama, which were, however, to be controlled by the United States in sanitation and quarantine affairs.

For these grants the U. S. paid $10,000,000 on the ratification of the treaty and after nine years an annual rental of $250,000 is to be paid.

On May 4th, 1904, the United States purchased the Panama Canal property at a cost of $40,000,000, and thus came into possession of property and rights which cost the French people $267,000,000 and many thousand lives to acquire.

In the meantime the President appointed a new commission to carry on the construction of the canal and govern the canal zone.

The Commission consisted of Rear Admiral John G. Walker, Chairman; Major General George W. Davis; Mr. William Barclay Parsons; Prof. William H. Burr; Mr. Benjamin M. Harrod; Mr. C. E. Grunsky; Col. F. J. Hecker.

In May, 1904, Mr. John F. Wallace was appointed Chief Engineer and Major General Davis was made Governor of the Canal Zone.

Col. Wm. C. Gorgas of the Medical Department, U. S. Army, whose successful work in the sanitation of Habana was so commendable, was made Chief Sanitary officer of the Zone.

On November 16, 1904, the Walker commission resigned to take effect at the pleasure of the President and a new commission was appointed as follows: Mr. Theo. P. Shonts, Chariman; Mr. Chas. E. Magoon, Governor; Mr. John F. Wallace, Chief Engineer; Rear Admiral M. T. Endicott, U. S. N.; Brig. Gen. Peter C. Hains, U. S. A.; Col. O. H. Ernst. Corps of Engrs.; Mr. B. M. Harrod.

On June 13, 1905, Mr. Wallace resigned and was succeeded by Mr. John F. Stevens as Chief Engineer.

On June 24, 1905, the President appointed a Board of Consulting Engineers consisting of Gen. Geo. W. Davis; Mr. Alfred Noble; Prof. Wm. H. Burr; Mr. Wm. B. Parsons; Gen. Henry L. Abbot; Mr. Fred. P. Stearns; Mr. Joseph Ripley; Mr. Isham Randolph; Mr. Wm. Henry Hunter, by the British Government; M. Guerard, by the French Government; M. Quellennec, Con. Engr. Suez Canal; Herr Eugen Tincauzer, by the German Government; Herr Welcher, by the Dutch Government; Capt. J. C. Oakes, Secy.

This Board was appointed for the purpose of considering the various plans proposed to and by the Isthmian Canal Commission for the construction of the Panama Canal. Minority reports were requested in case of differences in opinions among the members of this Board.

On February 5th, 1906, this Consulting Board submitted two reports, a majority report favoring a sea-level canal and a minority report advocating a lock canal with an artificial lake and summit level at 85 feet above sea level.

The minority report was signed by Messrs. Noble, Abbott, Stearns, Ripley and Randolph, and this report was proposed for adoption by the following members of the Commission: Messrs. Shonts, Magoon, Hains, Ernst, Harrod and Stevens.

It is the plan of this minority report which is at present being arried out with some slight modifications which became desirable as the work progressed.

In November, 1906, President Roosevelt visited the canal in person. At this time an Engineering Board consisting of Messrs. Alfred Noble, F. P. Stearns and J. R. Freeman was sent to the Isthmus to investigate and report on the foundations of the locks and dams.

In March, 1907, Mr. Stevens resigned his connection with the Commission and the President then appointed Col. George W. Goethals, Corps of Engineers, Chairman and Chief Engineer, and turned the entire work over to the Corps of Engineers, U. S. A.

In January, 1909, the President appointed a Board of Consulting Engineers consisting of Messrs. Frederic P. Stearns; Henry A. Allen; Arthur P. Davis; James D. Schuyler; Isham Randolph; John R. Freeman and Allen Hazen, to accompany President-elect William H. Taft to the Isthmus with instructions to look into the condition of the work and especially to report upon the feasibility and safety of the Gatun Dam and also to decide whether, or not, there should be any change in the plans at present adopted by Congress.

This Board returned from its duties and submitted a report February 17th, 1909, approving unanimously the type and dimensions of dam being constructed at Gatun and commending the general canal plans as at present adopted.

Brief Discussion of Five Isthmian Canal Projects

The American Isthmus, connecting Mexico with South America and embracing the Central American Republics, is a mountain ridge between the Sierra Madre and Andes ranges.

There are many high peaks up to 12,000 feet above sea level, and the ridge has occasional saddles which have been located so far as possible with a view of finding suitable canal routes.

At Tehuantepec, Mexico, the summit is about 700 feet, at Nicaragua it is 400 feet, at Panama 365 feet, and at Caledonia and San Blas over 1000 feet above sea level.

Owing to the peculiar S shape of the Isthmus of Darien, now commonly called Panama, the continuity of the range is somewhat interrupted, giving rise to the Culebra Pass.

Rivers are very numerous and during seven months of rainy season, when the rainfall reaches 140 inches at Colon and 180 in. at Nicaragua, these rivers discharge immense quantities of water and any canal project, if it be practicable, must provide for disposing of this water or in some way regulating the same without detriment to the Canal or to navigation.

Of all routes investigated by the Isthmian Canal Commission there are only four which warranted making any complete surveys and estimates and the results of these studies are given in the accompanying table.

The Tehuantepec route may be discarded at once on the grounds of length, high summit level and excessive cost, besides offering no

ESTIMATES OF ISTHMIAN CANAL PROJECTS FOR CHANNEL 150 FT. WIDE AND 35 FT. DEEP

Route	Length miles	Mx. Cut feet	Sum. feet	Locks	Total Excava. cubic yards	Cost dollars	Remarks
Panama Lock level	45	275	85	6	95,000,000	184,233,000*	Gatun Earth Dam, 115 ft. high x 8,200 ft.
Panama Sea Level	45	365	0	1	266,228,000	290,000,000*	Gamboa Masonry Dam, 200 ft. high x 5,000 ft.
Nicaragua Lock Level	184	324	110	8	227,400,000	189,864,000	6 Spillways, 1 Dam 132 ft. high x 1,000 ft.
Caledonia Sea Level	56	1050	0	1	235,000,000	263,340,000	1 Tunnel, 1.6 miles long, 120 x 155 ft.
San Blas Sea Level	40	1070	0	1	289,000,000	289,770,000	1 Tunnel, 4.2 miles long
Tehuantepec Lock Level	120		700	40		400,000,000	No water for locks and power

All above locks are estimated as twin locks, 84 ft. wide, 800 ft. long, 35 ft. deep.
Above estimates do not include right of way, sanitation, zone government, etc.
*The Panama estimates include $40,000,000 for purchase of French Company's property.

natural water supply for the 40 locks which are indispensable. This route came into prominence when Mr. James B. Eads proposed the construction of a ship railway.

The Caledonia and San Blas routes are similar in their general characteristics, being short and requiring ship tunnels as the only possible means of passing through the high summit levels of over 1000 feet each. The tunnel feature must be regarded as highly objectionable and these routes are therefore, rejected as impracticable.

This reduces the choice to two routes, the Nicaragua and the Panama, of which the latter alone is feasible for a sea-level canal, though both are practicable and feasible for a canal with locks.

On the basis of a lock canal the Panama route offers very obvious advantages, being only one-fourth as long, requiring less locks and about half as much excavation thus involving considerably less cost. Both routes offer ample water supply. The estimated annual cost of maintaining and operating the Panama Canal is about $1,300,000 less than for the Nicaragua Canal. The time required for ships to pass through the canal is also greatly in favor of the Panama route.

The only obstacle in the way of making a choice was found to be the purchase price originally held by the New Panama Co., but this was finally settled on a very advantageous basis.

The question of territorial rights would be common to all routes and was concluded in a most satisfactory manner with the state of Panama.

Hence after much study and most painstaking and diplomatic negotiations the United States selected, and acquired by purchase, the best route for an Isthmian Canal and also the route which offers the greatest possibilities from an engineering standpoint.

The questions still remaining for discussion are the choice between the sea-level type of canal and the lock type.

Sea Level Versus Lock Level Plan, Panama Canal

A *sea level canal*, according to the popular impression, is a waterway affording unrestricted navigation. The lock type of canal is assumed to be decidedly inferior to the former, owing to delays caused by mechanical appliances used in lifting and lowering vessels. These conceptions are quite inaccurate.

An ideal waterway would be a sea level canal of greater width than the length of vessels using it, since with less width such a channel could be easily blocked by the sinking of a ship transversely to the channel. This would require at least a 1000 ft. canal, which has never been proposed and could never be entertained. Hence, all who have seriously considered this question have been compelled to reduce the width to that strictly necessary for the largest vessels to pass at greatly reduced speed.

The original estimate by the Isthmian Canal Commission, in 1901, was based on a width of 150 feet, which is very far from furnishing unrestricted navigation. Large vessels, such as the Cunarders could not exceed a speed of say four miles per hour, nor could they pass inside this limit, even if there was sufficient depth of water to float them.

The lock type of canal can be so planned that for considerable distances, navigation may proceed, without restrictions, through artificially created lakes. The advantages thus afforded may by far outweigh the objections feared from the use of locks. Hence, it is quite conceivable that a lock canal might be better and offer greater facilities in ease and time of navigation, and be attended with less risk than a sea level canal.

However, there are many other features favoring the lock type of canal, in this particular instance, which are not understood by the layman until the more intricate engineering problems involved in both types are more clearly presented. See Figs. 1, 2 and 3.

The sea level canal will be a deep, narrow, tortuous, gorge, which no large ships can safely navigate except at very slow speed. A tide lock will be absolutely necessary on the Pacific end of the canal to take care of a fluctuation of about 22 ft. between high and low tides. The enormous flood waters of the Chagres River must be carried off or controlled and the extraordinary rainfall, amounting annually to 60 inches at Panama and over 140 inches at Colon, will cause dangerous silting-up of the excavated channels and this in turn will make the maintenance very costly.

The most serious of these factors, the control of the Chagres flood waters, invited many speculative schemes and formed the subject of much study and discussion. Either the canal itself must be made sufficiently large to carry off the maximum floods, or independent channels must be provided for that purpose.

As the canal was to occupy the lowest portion of the valley, the construction of such diversion channels would offer serious difficulties. The simplest solution would be to enlarge the canal prism sufficiently to carry the entire flood water; however, this proposition must be discarded at once on account of the extreme dimensions required, the swift currents produced and the silting-up of the channel from the various rivers emptying into the canal.

The most feasible plan proposed was to impound the flood waters from the upper Chagres valley behind a masonry dam at Gamboa, just off the canal line. This dam was to be 200 ft. high, over one mile long and to form a reservoir to be called Gamboa Lake, into which the upper Chagres water could be received and be gradually discharged into the canal prism at a maximum rate of 15,000 cu. ft. per sec. restricting the current to 2.6 miles per hour.

Other flood waters accumulating below this dam were to be diverted entirely from the canal and carried, by separate channels, to the sea. Some other tributaries and the Rio Grande, Gatun and Mindi Rivers would still remain to be taken care of either by similar dams or separate channels. The Rio Grande was to be diverted through a tunnel about one mile long. The Gigante River was to be controlled by a masonry dam 75 feet high and over one-half mile long.

The structures thus made necessary for flood water control, present

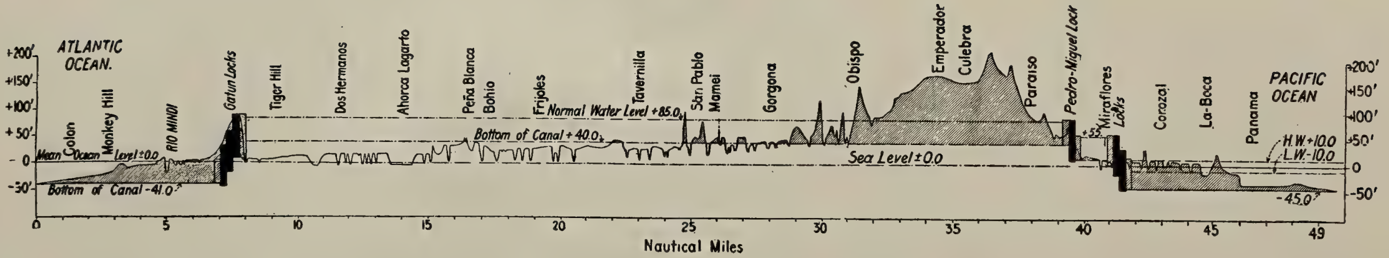

Fig. 2—Profile of Proposed Lock Level Canal

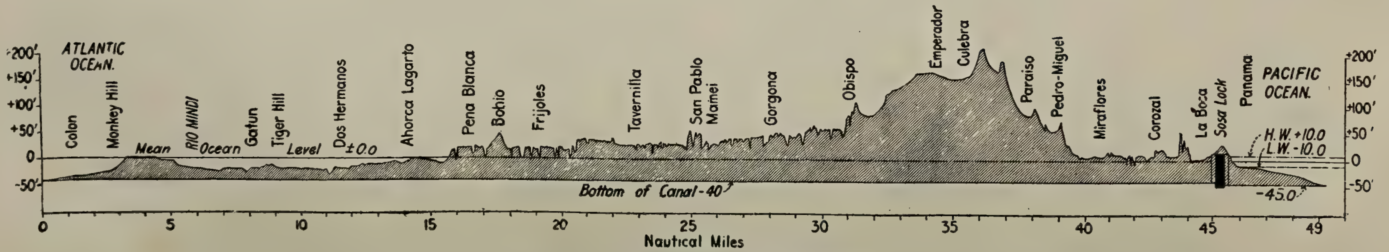

Fig. 3—Profile of Sea Level Canal

far more hazardous and untried features than any of the proposed locks and dams and would cost approximately as much to build and maintain.

The mere increased excavation is, therefore, only a comparatively small objection, easily measurable in money, contrasted with the engineering difficulties involved in the sea level project. The time for construction was variously estimated at from 16 to 20 years, and the cost including $40,000,000 for purchase, was estimated at $290,000,000 for the sea level canal 150 feet wide and 35 feet deep.

The Much Criticised Plan for a Lock Canal

The principal feature of this plan as finally adopted, is an earth dam at Gatun designed to close the Chagres valley at a point only 5 miles from Colon, thus forming an immense inland lake into which all the tributary rivers could empty. This lake, to be known as Gatun Lake, will store sufficient water to supply the needs for the locks and to generate electricity for operating the canal. It will be maintained at an elevation of from 80 to 87 feet above sea level, will have an area of about 164-square miles and will effecctually regulate all the flood waters north of the Culebra Cut without producing any measurable currents or silting in the navigable channel.

At Gatun the vessels will be raised 85 feet through three flights of twin locks and this level will be retained over the greater length of the canal to Pedro Miguel where a single flight of twin locks will lower the level to 55 ft. above the sea into Sosa Lake.

This is another artificial lake to be created by a dam at the Pacific end, which dam will close the valley of the Rio Grande and thereby regulate the flood waters from this river. The final descent into Panama Bay was then to be accomplished by two flights of twin locks at Sosa. By a change in plan the Sosa locks are now located at Miraflores for military reasons, but this does not affect the general features of the canal except to add something to the cost of excavation, though the Sosa dam disappears.

While the Culebra Cut was planned with a bottom width of 150 ft. as in the sea level project, nearly 70 per cent. of the entire canal would be 500 ft. or more in width, and include about 20 miles of lake navigation affording a width of 1,000 ft. and over, with a depth of 35 to 70 feet.

The estimated cost for this type of canal, including purchase of the French property, was figured at $184,233,000, or ⅝ as much as for a similar sea level canal with uniform width of only 150 ft. The time of completion was estimated as 10 years.

In conclusion then the very considerable differences in cost and time of completion, which speak so decidedly in favor of the lock type of canal, ought to afford a vastly superior waterway on the sea level plan if the added expenditure of time and money be justified. The choice should fall to that type which offers the greatest safety and ease to navigation within the limits of engineering and financial possibility. If the most costly structure be not also the best, then the result will be discreditable and scandalous.

The question of safety and ease to navigation depends both on the nature of the waterway and the crafts using it. Accidents to the waterway may stop traffic or merely retard it, or may not affect it at all, depending on the nature of the accident.

It has been demonstrated that the risk of serious injury to a well-equipped canal lock is exceedingly small and for the twin lock system with duplicate gates provided in the Panama lock designs this factor is practically eliminated except in time of war. At such time either form of canal would require efficient military protection which is equally practicable for either type of canal.

Experience on the world's great waterways has shown that ships are far more liable to delay and injury while traversing artificial channels at considerable speed than when passing locks where they move slowly and under perfect control. The narrower the channel the greater the danger of collision, groundings, blockades, and injuries to ships.

In consequence of the wider and better channel afforded by the lock canal, ships could pass through at far greater speed and with comparatively little danger to accident and this would greatly exceed the slight inconvenience and loss of time in passing the locks. The term "provisional" so commonly applied to the lock canal is, in reality, better suited to the sea level type of canal, a fact not known to the average readers of the daily papers.

To sum up the comparative engineering features we may add that a sea level project must include a tide lock at Sosa or Miraflores; a dam 200 feet high at Gamboa, where the site is so unfavorable that a masonry dam is unavoidable with foundation 50 ft. below the Chagres River bed; either spillway cuts must be provided through this dam, or long tunnels, larger than the new Swiss, double-track tunnels, must be built through unknown geologic formations; and about 40 miles of artificial and very costly diversion channels must be built in the immediate vicinity of the canal. All these items according to the most approved plans yet proposed must be added to the huge excavation through the continental divide, which of itself proved so disastrous to the French undertaking and forced that company to definitely abandon the sea-level construction many years ago.

By the lock type of canal these features are all removed, the tributary rivers are all transformed from formidable enemies into welcome friends, the amount of excavation is reduced to a minimum, and the only structures of any importance are the Gatun earth dam and the locks, all of which are absolutely feasible and now nearing completion.

In view of the apparent advantages thus to be obtained from the lock canal, Congress, on June 29, 1906, authorized the construction of the canal in accordance with this recommendation which was proposed by the Isthmian Commission of 1901, and more thoroughly discussed and again advocated by a minority of the Board of Consulting Engineers, in 1906, receiving the approval and support of the Commission, the Secretary of War, and the President of the United States.

Work is being prosecuted along these lines with very satisfactory results, and all former estimates relative to rate of progress and engineering possibilities are being realized beyond expectation.

The Lock Level Plan as at Present Adopted

In the interests of navigation it was found desirable to change many minor details as to dimensions of locks, widening the Culebra Cut successively from 150 to 200 feet and finally to 300 ft., also widening the ocean approaches, and deepening the entire canal to 41 feet, with 45 feet in the approaches, etc. All these changes, together with the cost of sanitation and canal zone government, increased the original 1901 estimate from $184,233,000 to $375,200,000 as shown by the following revised estimate:

Estimate for 85 ft. Lock Level Canal 300 to 1000 ft. wide and 41 to 45 ft. deep, January, 1909.

Original Board estimate for 150 ft. Channel	$144,233,000
Purchase of Canal property from French Co.	40,000,000
Republic of Panama for Canal Zone	10,000,000
Sanitation and Canal Zone Government	27,435,000
Increase in locks to 110 x 1000 ft. x 41 ft. deep. 80,000,000 c. y. increased excavation. Increased cost of labor for 8 hr. day	97,250,000
Cost of plant, steamship line and 20 per cent. for contingencies	56,283,000
Total	$375,201,000
Credits from Panama R. R. Loans, etc.	15,000,000
Net	$360,201,000

An estimate for a sea level canal, 300 ft wide and 41 ft. deep over the main portions would be about $563,000,000, and require until 1921 to complete.

It is confidently estimated that the canal can be completed on the revised and adopted plan by January, 1915, which would require the work of excavation to proceed at the rate of less than 2,000,000 cu. yds. per month, while in reality over 3,000,000 per month were excavated during the year 1908, and the maximum for any single month was nearly 3,500,000 cubic yards.

During the French occupation, a total of 78,147,000 cubic yards was excavated of which about 29,908,000 cubic yards are useful to the present project.

The work of excavating by the United States was necessarily slow at first owing to the lack of sufficient digging machinery which could not be supplied on short notice.

The number of steam shovels and dredges was gradually increased until Jan., 1908, since which time about 100 steam shovels and 18 dredges have been at work.

Work Accomplished to Feb.1, 1913.

Excavation about 91% completed	
Usable excavation by the French	30,000,000 c. y.

Excavated by the U. S.	190,000,000 c. y.
Required to complete	22,000,000 c. y.
Total excavation	242,000,000 c. y.
Fill in Gatun Dam, completed	22,000,000 c. y.
Concrete in Locks, Dams and Spillway, 96% completed	
In place	4,503,000 c. y.
Required to complete	167,000 c. y.
Total concrete	4,670,000 c. y.
Steel in 46 lock gates, 58,000 tons. Nearly all delivered and about 65% erected.	
Total estimated cost	$375,000,000
Disbursed to Jan. 1, 1913	277,000,000

When the canal is completed according to the above estimate and plan, the United States will own not merely the canal but also the Panama R. R., the steamship line and a construction plant which has cost about $30,000,000.

A few words regarding the "scandal-mongering literature" so current in the daily papers, may be added here. All the statements made and investigated have been traced to interested complainants or to a class of reformers who are not acquainted with the facts and who at the expense of truthfulness, are seeking notoriety. In the language of the former Chairman of the Commission, Mr. Theo. P. Shonts, "the only discredit inhering in these false accusations is to those who originate and give them currency, and who, to the extent of their abilities, thereby hamper and obstruct the completion of the great work in which both the honor and the interest of America are so deeply involved. It matters not whether those guilty of these false accusations utter them in mere wanton recklessness or folly or in spirit of sinister malice to gratify some personal or political grudge."

Ex-President Roosevelt in his message to Congress, dated Feb. 17, 1909, referring to the report of the recent Board of Consulting Engineers who visited the Isthmus, said, "I am happy to report to you that the accompanying document shows in clearest fashion that the Congress was wise in the position it took, and that it would be an inexcusable folly to change from the proposed lock canal to a sea level canal. In fact, this report not only determines definitely the type of canal, but makes it evident that hereafter attack on this type—the lock type—is in reality merely attack upon the policy of building any canal at all."

To this the writer would add that the navigator who, in the future, will use this waterway will be the first to protest against any scheme having for its object the change from a lock canal to one of the sea level type.

The Safety of the Canal

So much adverse criticism regarding the safety of the Gatun dam and the locks has appeared in the daily press, that a few words should be directed to this subject.

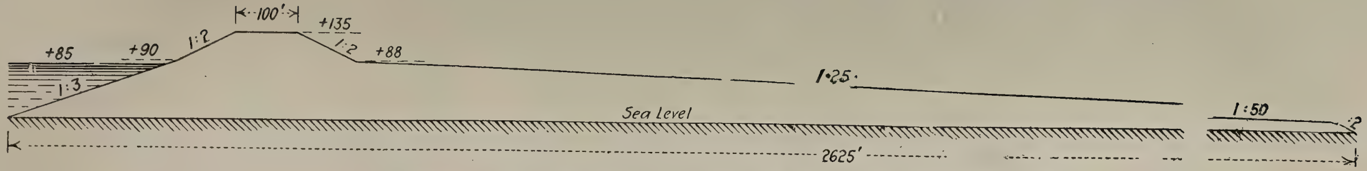

Fig. 4—Original Sketch, proposed by Board of Consulting Engineers, 1906

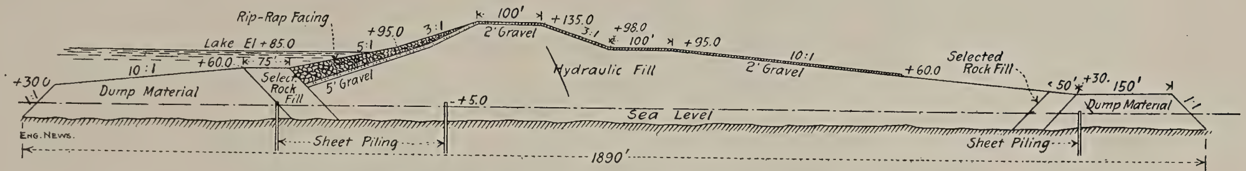

Fig. 5—Modified Section, proposed by Isthmian Canal Commission, 1908

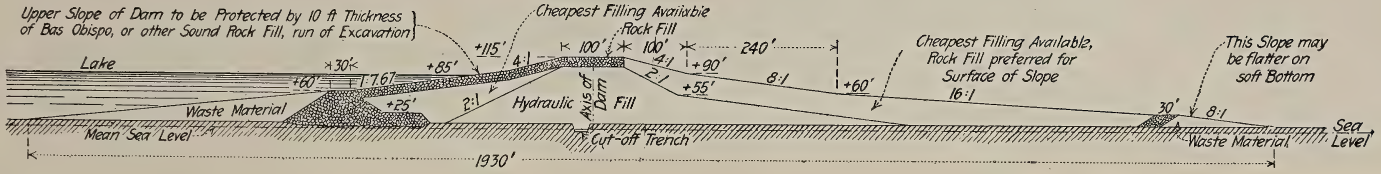
Upper Slope of Dam to be Protected by 10 ft Thickness of Bas Obispo, or other Sound Rock Fill, run of Excavation
Cheapest Filling Availabie Rock Fill
+115'
4:1
100'
100'
240'
4:1
+90'
2:1
+55'
8:1
+60'
Cheapest Filling Available, Rock Fill preferred for Surface of Slope
16:1
This Slope may be flatter on soft Bottom
Lake
30'
+85'
+60'
1:7.67
+25'
2:1
Hydraulic
Axis of Dam
Fill
Waste Material
Mean Sea Level
Cut-off Trench
30'
8:1
Waste Material
Sea Level
1930'

Fig. 6—Adopted Section, proposed by Board of Consulting Engineers, 1909

It is significant that all the pet schemes of certain individuals and many untried methods proposed by inventors of excavating machinery together with the objections of prospective contractors, should gain free advertisement by some 10,000 newspapers under the guise of pointing out dangers to be feared from the adoption of the present plans.

This condition has prevailed to such an alarming extent that when the truth is occasionally told by some responsible engineering authority, as the recent Board of Consulting Engineers who accompanied President Taft to the Isthmus, such facts are either ignored or ridiculed.

These pernicious practices have brought about a sad condition of affairs which, if directed against any private enterprise, would certainly have proven disastrous. It is only through the strenuous efforts of those in high authority that the good work has been permitted to continue.

No technical argument, worthy of serious consideration by the engineering profession, has appeared among the lately published criticisms concerning the Panama plans and work. Yet these alarmist reports have a wonderful influence in warping public opinion, and this is undoubtedly the underlying motive to which the public press has innocently become a party.

"A little word is not a little thing;
For it may make, and it may mar a King."

It is scarcely possible to find an example of engineering design which embodies such a high factor of safety throughout as do the designs for the locks and dams of this canal. So great was this conservatism on the side of safety, that the recent Board of Engineers recommended reducing the height of Gatun dam by 20 ft., leaving its crest 30 ft. above the level of Gatun Lake instead of 50 ft. as originally planned. See Figs. 4 to 7.

The increased width of the narrow portions of the canal from 150 to 300 feet and the greatly enlarged lock chambers were adopted to increase the safety to vessels navigating the canal. The deepening of the entire canal from 35 feet to 41 and 45 feet is another feature which will permit the larger vessels to proceed at greater speed.

The locks are all designed of most massive concrete monoliths and arranged in duplicate so as to separate up and down bound traffic and in case of necessary repairs one lock may be temporarily thrown out of commission without interfering with traffic. Duplicate gates are also provided for the case of local damage, should any occur. About five million cubic yards of concrete will be utilized in their construction.

As a further safety, the several lake outlets are all to be guarded by emergency dams of the movable type, so that in the remote possibility of any serious accident the summit level will be maintained while repairs are carried on. All this may never be needed but it is provided as an absolute safeguard against any possible contingency.

The possibility of an earthquake has also been erected by fancy into a threatening danger. If such creations of the imagination are to serve as a guide, then the earth is no place for any great work.

There are 116 volcanoes within a radius of 1200 miles from Panama, and half of these are active. Within a radius of 500 miles about Nicaragua, may be counted 43 extinct and 37 active volcanoes. One active volcano is situated within eleven miles of the proposed Nicaragua route and one within 200 miles of Panama, yet private corporations were prepared to venture investments in both localities.

The famous straight arch (26 ft. span and 7 ft. rise) in the ruins of the old Santo Domingo Convent at Panama, and the stone arch over a river near the old city of Panama, both of which have stood over two centuries, would certainly have collapsed during any serious manifestations of seismic disturbance. There was a more or less destructive earthquake at Panama in 1621, but none of any importance were recorded since.

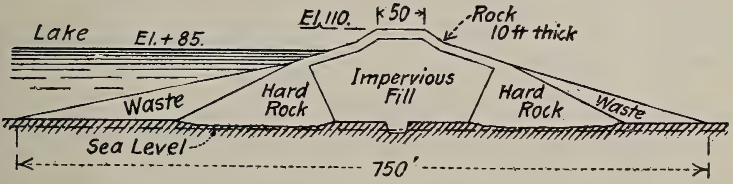

Fig. 7—Section proposed by "Engineering News" as Safe Design

However, in the event of any such disturbances, the resulting damage to a sea level canal with a masonry dam at Gamboa, would be even more disastrous than that to any of the locks or dams now proposed in the present project.

Climatic, Sanitary and Social Conditions

Possibly the greatest danger which attended the Isthmian undertaking and which, to a high degree, brought about the failure of the French Company, was the danger to life. This fact was carefully considered by the Commission, and a most vigorous campaign was immediately instituted for the establishment of sanitary conditions especially in the terminal cities, Colon and Panama.

The department of health and sanitation was thus created and after adopting most stringest sanitary measures, has reduced Malaria to comparative insignificance, while Yellow Fever was stamped out on the Isthmus since May 1, 1906.

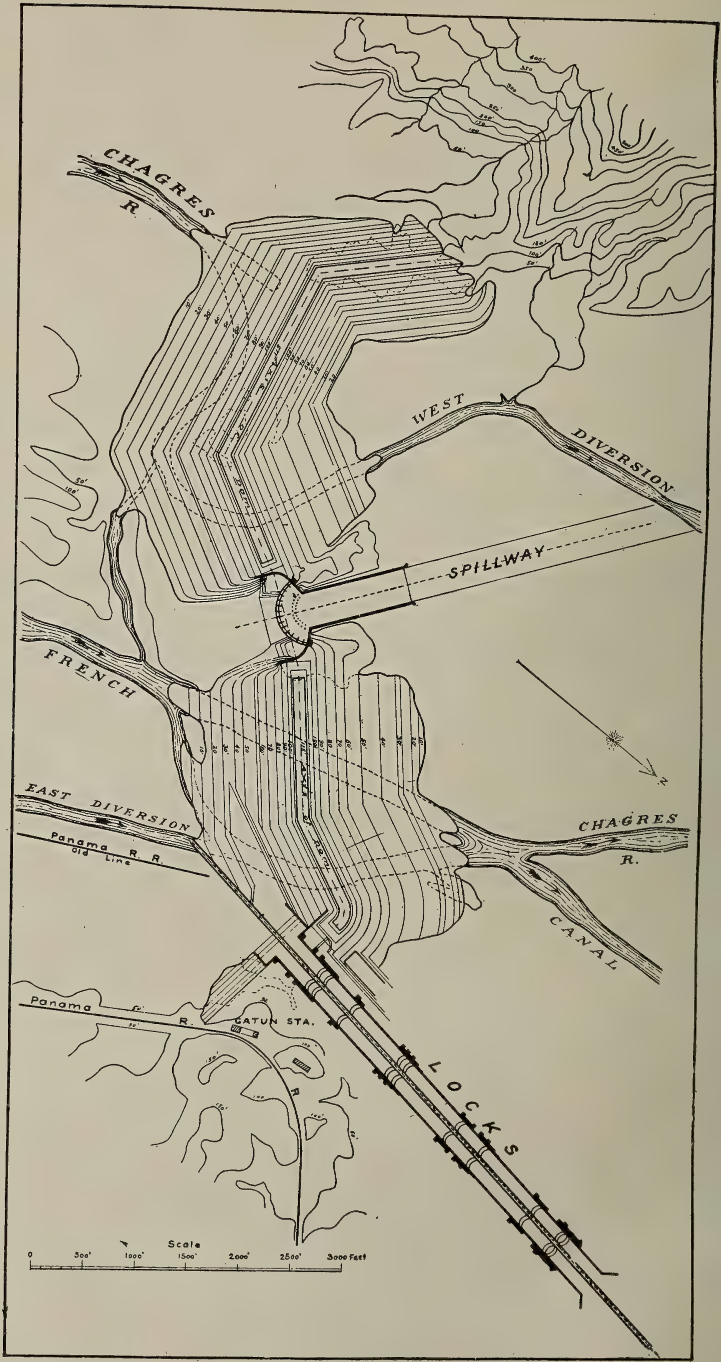

Fig. 8—Plan of Gatun Locks and Dam.

Considering the whole population of Panama, Colon, and the Canal Zone, we have the following health record:

YEAR	POPULATION	DEATH RATE PER THOUSAND
1904	35,000	52.45
1905	42,699	50.57
1906	66,011	51.89
1907	102,133	33.45
1908	120,097	29.17
1909	125,000	16.42
1910	145,000	19.00
1911	154,000	17.67

From 1881—9, during the French occupation, the average number of deaths per 1000 was 28.5 due to Yellow Fever and Malaria alone. During the past year, with a population of over 150,000, this number was reduced to 1.8 per 1000 due to Malaria and none due to Yellow Fever.

The mosquito theory regarding the transmission of these fevers is now generally accepted and through the discoveries of Ross, Lavaran and Reed, a most valuable service was rendered to science. By this discovery the United States was enabled to overcome what seemed to be to the French an insurmountable obstacle.

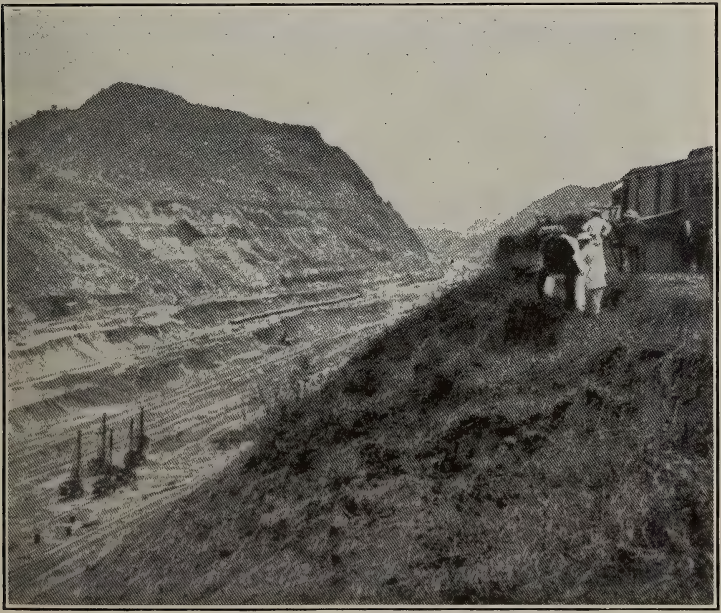

Fig. 9—View of Culebra Cut from Y.M.C.A. Observatory

By treaty the United States secured the right to enforce sanitary regulations over the entire Canal Zone and the terminal cities. An immense amount of labor and money has been thus expended in clearing the Canal Zone, exterminating the mosquito by applying crude oil to all the breeding places and providing the entire Zone with a good water supply. The cities of Colon and Panama were cleaned up, paved and sewered and are now as healthy as any of our northern towns.

The Isthmian climate is not at all unhealthy. Five months of the year, including January, February, March and April, constitute the dry season, and the temperature never falls below 64° nor rises above 97° in the shade. The average daily range is from 75° to 84°, with little variation between summer and winter, wet and dry seasons. The high humidity, ranging between 80 and 87% exerts a very exhausting and oppressive influence on the white races. The negro races are not so seriously affected.

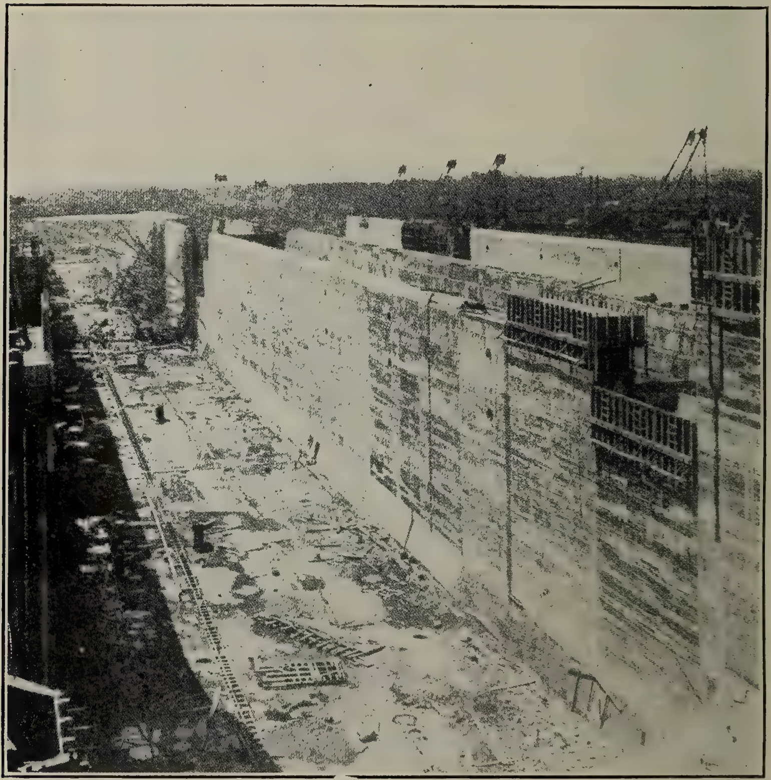

Fig. 10—Gatun Middle Locks, Panama Canal

The average annual rainfall during a period of 33 years, between

1871 and 1904, was 64.7 inches at Panama, 94.9 inches at Gamboa and 137.2 inches at Colon.

The Canal employees are being well cared for, are provided with comfortable and sanitary quarters, and can receive all the necessary wants of life from the Commissary Department at practically the same prices as in the United States.

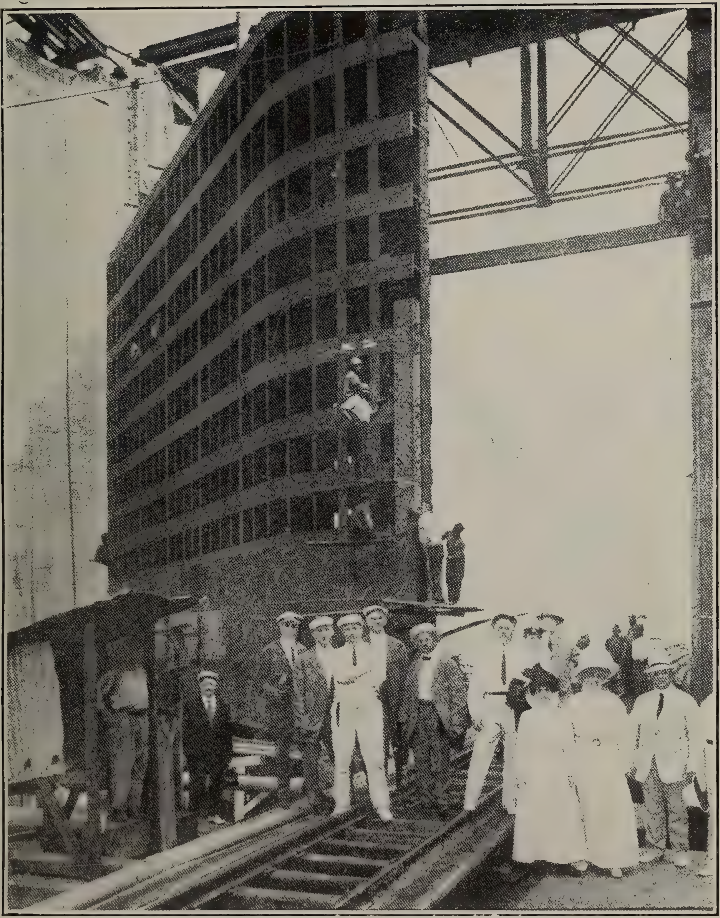

Fig. 11—Gatun Locks, Panama Canal

Artificial ice is produced at Colon and there are several steam laundries and bakeries, all owned and operated by the government.

Many Social Clubs now exist, though several years ago this feature was absent. Various outdoor sports such as baseball, tennis, etc., are indulged in.

Let us hope that this great work may continue without further impediments savoring of politics, scandals and investigations, and that the United States may win the prize among nations in demonstrating their ability to complete another "world wonder," which nearly crippled one of the foremost European nations, and is now on a fair way to successful completion.

Canal Statistics.

Length from deep water to deep water	50½ miles.
Length on land	40½ miles.
Bottom width of channel, maximum	1,000 feet.
Bottom width of channel, minimum, 9 miles Culebra Cut	300 feet.
Locks, in pairs	12
Locks, usable length	1,000 feet.
Locks, usable width	110 feet.
Gatun Lake, area	164 sq. m.
Gatun Lake, channel depth	85 to 45 feet.
Excavation, estimated total	242,504,000 c. y.
Excavation, by the U. S. to Feb. 1, 1913	190,000,000 c. y.
Excavation by the French	78,146,960 c. y.
Excavation by French, useful to present Canal	29,908,000 c. y.
Concrete, total estimated for Canal	5,000,000 c. y.
Time of transit through completed Canal	10 to 12 hours.
Time of passage through locks	3 hours.
Relocated Panama Railroad, estimated cost	8,866,400
Relocated Panama Railroad, length	47.2 mile
Canal Zone, area	about 436 sq. m.
French buildings, number required	2,150
French buildings, number used	1,537
French buildings, net value when acquired	$1,959,203
Value of utilized French equipment	1,000,000
Canal force, actually at work	about 36,000
Canal force, Americans	about 5,000
Cost of Canal, estimated total	$375,000,000
Work begun by Americans	May 4, 1904
Date set for official opening	Jan. 1, 1915

THE DIRECT DETERMINATION OF OXYGEN IN ORGANIC COMPOUNDS*

By Maitland C. Boswell.

Oxygen is one of the most frequently occurring constituents of organic compounds, and yet there is no direct method known for its quantitative determination. In the analysis of a compound the universal custom has been to determine the percentage of all the elements present with the exception of oxygen, subtract the sum of these from one hundred, and call the remainder the percentage of oxygen. Although this has presented no serious impediment to the development of organic chemistry, yet many instances have occurred in which a method for the quantitative estimation of oxygen would have been a great convenience. No doubt most organic chemists have in the course of their synthetic investigation work met with reactions involving considerable alteration in the oxygen content of a compound without changing to any appreciable extent the percentages of carbon and hydrogen present, as, for instance, in the replacement of the amino group by hydroxyl. Moreover, a direct method for oxygen is also needed for its determination in commercial products as asphalt, rubber, etc., and for following the course of reactions involving the fixation of atmospheric oxygen in compounds Several indirect methods have been worked out by Baumhauer,[1] Ladenburg,[2] Maumené,[3] Mitscherlich,[4] Persoz,[5] Strohmeyer,[6] Wanklyn and Frank,[7] Cretier,[8] and others. All of these suffer from the complications and consequent inaccuracies of indirect methods. None of them have come into general use, and many of them, such as the method of Mitscherlich for the determination of C. H. O. N. Cl., Br., I and S in one operation, have probably not been performed since the original experiments by the investigators themselves.

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* Published in the Journal of the American Chemical Society, Vol. 35, No. 3, March, 1913

The method described in this paper consists in the determination of the amounts of water, carbon dioxide and carbon monoxide formed when a weighted amount of substance is heated in a quartz tube to a high temperature in a current of pure hydrogen, the products of the reaction being passed over a long layer of charcoal particles heated to a white heat. In the presence of the two strong reducing agents, hydrogen and carbon, at a high temperature, all the oxygen in the original compound is converted into the simple compounds water, carbon dioxide and carbon monoxide. The hot carbon also reacts with the water, forming carbon monoxide and hydrogen, and likewise reduces some of the carbon dioxide to monoxide. However, not only are both of these reactions reversible, but in the passage of the gaseous mixture through the hot tube they probably do not reach equilibrium. Hence water and carbon dioxide are always observed among the reaction products. The water is absorbed in conc. sulphuric acid, the carbon dioxide in soda-lime and the carbon monoxide determined by a modification of the method of Levy,* which consists in passing the gas from which the water and carbon dioxide have been removed through iodine pentoxide and the determination of the carbon dioxide formed in the oxidation by absorption in soda lime.

Description of Apparatus.

A is a quartz tube 13 mm. in internal diameter, and 980 mm. in length. Commencing 135 mm. from one end a layer of charcoal particles about 1 c. mm. in size, free from powdered charcoal, is packed tightly in the tube for a length of 400 mm. and held in place by asbestos plugs at each end. This tube is set in a "combustion furnace" of the usual form, except that the iron trough and tiling supporting the combustion tube are omitted, and the iron work

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(1) *Ann.*, **90,** 228 (1854); *Jahresb*, **1855,** 768; *Z. Anal. Chem.*, **5, 141** (1866).
(2) *Ann.*, **135,** 1 (1865).
(3) *J. prakt. Chem.*, **84,** 185 (1861); *Compt. rend.* **55,** 432 (1861).
(4) *Pogg. Ann.*, **130,** 536 (1841); *Z. Anal. Chem.*, **6,** 136 (1867); *Ber.*, **1,** 45 (1868); *Ibid.*, **6,** 1000 (1873); *Ibid*, **7,** 1527 (1874); *Z. Anal. Chem.*, **7,** 272 (1868); *Ibid.*, **15,** 371 (1876).
(5) *Ann. Chim. Phys.*, **75,** 5.
(6) *Ann.*, **117,** 243 (1851).
(7) *Jahresb*, **700,** (1863).
(8) *Z. Anal. Chem.*, **13,** 1 (1874).

(*) *J. Soc. Chem. Ind.*, **30,** 1437 (1911).

supporting the trough also, if possible, removed so as to avoid any transfer of heat to the substance during the preliminary heating of the charcoal. Two asbestos board protectors *a*, *b*, are cut so as to fit tightly across the furnace, one 15 mm. from the end of the charcoal layer, and the second 30 mm. from the first. If these are cut so as to fit tightly around the quartz tube and along the sides of the furnace, it is possible to heat the entire charcoal layer to a white heat in a rapid current of hydrogen, and thus clear the tube of all free oxygen and oxygen compounds, without warming in the least the silica boat *c* containing the weighed amount of substance, which rests 60 mm. from the nearer asbestos protector. The remainder of the tube *A* is empty.

The *Hydrogen Generator.*—The hydrogen is produced electrolytically in the generator *B*. This consists of a heavy outer glass vessel, *e*, 600 mm. in height and 130 mm. in diameter, containing dilute sulphuric acid (1:6) and having an inner glass tube *d*, 690 mm. in length and 35 mm. in diameter, open at the lower end and reaching almost to the bottom of the containing vessel. Both electrodes are of heavy lead, the anode being in the outer vessel and raised 60 mm. from the lower end of the inner vessel containing the cathode *w*. The cathode tube is closed by a rubber stopper with two holes, through one of which passes a bent glass tube, *h*, to conduct away the hydrogen, and through the second passes the **U** tube *g*, full of mercury and carrying the insulated conductor to the cathode. A current of cold water is made to circulate through a lead tube wound around the cathode vessel. This generator is connected up with a lamp rheostat and an ammeter to the street current of 110 volts. The hydrogen so generated contains an appreciable amount of oxygen which is removed by passing the gas through a quartz tube, *C*, 360

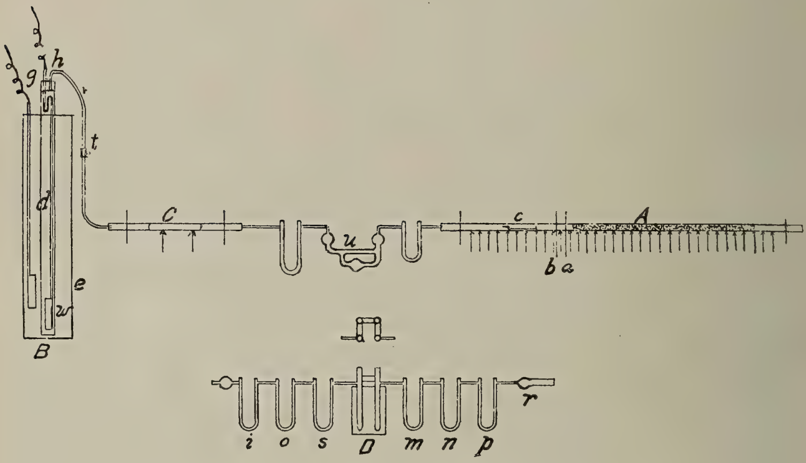

Fig. 1—Apparatus for the Direct Determination of Oxygen in Organic Compounds

mm. in length and 13 mm. internal diameter, containing a tightly wound coil of copper gauze 130 mm. in length, which is heated to white heat in a small furnace of two flat, wide flames. The hydrogen from this passes first through a **U** tube containing calcium chloride, then through a sulphuric acid dryer *u*, of special form,[1] which causes very thorough contact of gas with acid with very small friction and pressure head, and finally through a **U** tube containing phosphorus pentoxide from whence it passes into the main tube *A*.

Absorption Apparatus.—This consists of three parts—that for the absorption of water, that for the absorption of carbon dioxide, and that for the oxidation of carbon monoxide to dioxide and absorption of the dioxide thus formed. For the reasons given by Benedict[1] it is advisable to use conc. sulphuric acid on pumice for the first absorption. An ordinary calcium chloride **U** tube, *i*, with a bulb is filled with small pieces of pumice about 1 c. mm. in size, and so much conc. sulphuric acid is run in that a seal is just made at the bend, after impregnating the pumice. The carbon dioxide is preferably absorbed by moist soda lime made by the method of Benedict[2] and cut into pieces about 1 c.mm. in size and held between asbestos plugs in a **U** tube with limbs 120 mm. long and 11 mm. in diameter. A **U** tube *s*, of pumice moistened with conc. sulphuric acid, follows to retain the moisture carried over from the soda lime. The method of determining the carbon monoxide is a modification of that devised by Levy. The iodine pentoxide apparatus *D* shown in elevation and plan in the figure, consists of two **U** tubes 14 mm. diameter joined together on one side about 110 mm. from the bottom by a tube of about the same diameter. One **U** is filled with rolls of copper gauze, the other is filled with iodine pentoxide on asbestos made by impregnating enough asbestos to fill the tube with a solution of 25 or 30 grams of iodine pentoxide or iodic acid in water, evaporating to dryness on the water bath and heating in a vacuum at 250° C for several hours. The ends of the **U** tubes are then carefully sealed and the entrance and exit tubes carefully stoppered when not in use. During the analysis this is heated in an oil bath at 160°—170° and connected with the tube *s*. The carbon monoxide is oxidized to dioxide completely while the methane, ethane and hydrogen are unacted on, provided the gas is dry and no ethylene or acetylene hydrocarbons are present. The iodine liberated condenses for the most part in the wide connecting tube, the last traces being removed by the copper. As it is very difficult to completely free iodine pentoxide from iodic acid,[3] provision must be made for removing the moisture liberated when any iodic acid is reduced by the carbon monoxide. This is effected by a **U** tube *m*, containing sulphuric acid on pumice. The gas is then led into a **U** tube *n*, containing soda-lime, similar to tube *o*, and this is followed by a **U** tube *p*, of sulphuric acid on pumice similar to *s*. The absorption train is completed by a straight calicum chloride tube *r*, to prevent absorption of moisture from the air.

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(1) *Trans. Farady Soc.*, **6**, 10 (1910).
(2) *American Chemical Journal*, **23**, 323 (1900).
(3) *Compt. rend.*, **153**, 1226-9; *C. A.*, **6**, 721.

Method of Conducting the Analysis

Approximately three-tenths of a gram of substance is carefully weighed out in a silica boat, which has been cleaned, heated in the blast flame, and cooled in a desiccator. The five absorption vessels are weighed, care being taken to rub each vessel to constant weight with clean dry cheese cloth. The necessity for this must be emphasized because the analysis involves ten separate weighings. The boat containing the substance is now inserted in the tube *A*, care being taken that it is not closer than 60 mm. from the nearer asbestos board *b*. The hydrogen apparatus is connected to the tube by means of a rubber stopper and the apparatus tested for any leak under the full head of acid in the generator *B*. The flames under *C* are now lighted and when the quartz tube is glowing under the entire portion holding the copper gauze, the hydrogen is allowed to pass in a very rapid stream by regulating the screw pinch cock *t*. In a couple of minutes the burners extending from the asbestos board *a*, to the end of the furnace are lighted and turned full on. In three or four minutes this part of the tube is glowing. The rapid current of hydrogen is continued for four or five minutes longer. The rate is then considerably diminished and the absorption tubes connected by means of a tightly fitting rubber stopper. The remainder of the absorption apparatus is then connected in the order described above and the temperature of the oil bath *D* raised to 165°—170°. The rate of hydrogen is now still further diminished so that there is an actual but very small movement of gas through the apparatus. The burners at the other end of the furnace are now lighted, and very gradually the substance is warmed and finally heated with the full flames. The hydrogen current is continued for 15 minutes after this, the rate being somewhat increased during the last ten minutes in order to drive over all the gaseous products of the reaction. The success of the determination depends largely on the very gradual heating of the substance. The heating of the tube from the first lighting of the flames under the charcoal till the complete sweeping over of the reaction products requires about 1½ to 1¾ hours. The absorption apparatus is then detached from the apparatus *D* and the tube *m*, and dry air free from carbon dioxide passed through the five vessels for ten minutes. The tubes are then detached, allowed to remain in the balance room for an hour, observing the usual precautions, and weighed, care being taken to wipe each to constant weight.

Results

In calculating the amount of oxygen in the substance from the increase of weight of the absorption vessels, it must be borne in mind that although the increase in the tubes *n* and *p* following the iodine pentoxide apparatus represents the weight of carbon dioxide absorbed, yet one half of the oxygen present in this carbon dioxide has come from the iodine pentoxide and not from the substance. The substances analysed were thoroughly purified by repeated crystallizations of each from two solvents and where possible, by sublimation.

The purity was verified in some cases by constancy of melting point and where this was incapable of determination, by an analysis of the compound for carbon and hydrogen.

Substance	1	2	3	4	5
Cane Sugar.........	.3020	.0775	.0700	.1008	.0689
Succinic Acid........	.2864	.0532	.0506	.1772	.0473
Dimethyl Oxal......	.2978	.0292	.0477	.2752	.0259
Phthalic Anh.........	.3024	.0262	.0187	.1721	.0233
Vanillin.............	.2893	.0132	.0100	.2015	.0117

Substance	6	7	8	9	10
Cane Sugar.........	.0509	.0366	.1564	51.8	51.5
Succinic Acid........	.0441	.0644	.1558	54.4	54.2
Dimethyl Oxal......	.0347	.1001	.1607	54.0	54.2
Phthalic Anh.........	.0136	.0626	.0995	32.9	32.4
Vanillin.............	.0073	.0733	.0923	31.9	31.6

Column (1) gives the weight of substance taken,
Column (2) gives the weight of water formed,
Column (3) gives the weight of carbon dioxide formed,
Column (4) gives the weight of carbon dioxide formed by oxidation of monoxide,
Column (5) gives the weight of oxygen corresponding to the water in Col. (2),
Column (6) gives the weight of oxygen corresponding to the carbon dioxide in Col. (3),
Column (7) gives the weight of oxygen corresponding to the carbon dioxide in Col. (4),
Column (8) gives the weight of total oxygen, the sum of (5), (6) and (7),
Column (9) gives the percentage of oxygen found,
Column (10) gives the percentage of oxygen calculated from the formula.

It is seen on comparison of the oxygen percentages calculated from the formulas with the percentages actually found, as shown in columns 9 and 10, that the method is capable of about the same degree of accuracy as the combustion method for determining carbon and hydrogen, when this latter is very carefully conducted. This is considerably better than at first sight would seem possible, judging from the nature of the process. It might reasonably be expected that even though all the oxygen of the compound analysed should appear in the reaction product in the form of water, carbon dioxide and carbon monoxide, that stable compounds of carbon and hydrogen might be formed which might partly condense in the absorption apparatus and thus vitiate the result. It would be very surprising if in the application of this method to a great variety of compounds some cases of this kind are not encountered. However, under the conditions of the determination as described above (the very slow distillation over the very long and very hot carbon layer in a current of hydrogen) this objection does not apply, at least, to the compounds analysed, and these are fairly representative. Should this objection, however, in any case be observed, it could very probably be eliminated by the use of a small weighed amount of pure oxidizing agent of definite oxygen content, as potassium permanganate, intimately mixed with the substance in the boat.

It is the intention to proceed in this laboratory with the investigation of this or other means of obviating this possible source of error, and also with the application of the method to compounds containing nitrogen and other elements.

THE ANNUAL DINNER

All biased enthusiasm might be expected to have quite subsided during the past six weeks, and since in that interval none but optimistic tone has commented upon the twenty-fourth annual dinner of the Engineering Society, the event, like the Engineering Dance, must have been a success, truly. The dinner committee centered its efforts upon introducing into the affair a variety of enjoyment and amusement. The result was a capacity attendance—a most encouraging turn-out of undergraduates and a fine representation of graduates.

President Ritchie had many distinguished guests on either side and their short and pithy speeches were ably interspersed with instrumental selections by the "Toike Orchestra," the "Symphony Orchestra," and Mr. Evans, violin soloist, while Mr. E. F. McGarvey, baritone, and the Science Octette, under the leadership of Clayton Bush, '07, furnished the vocal music. Mr. "Rube" Dickenson, from a local theatre, also contributed to the program.

The toasts were those to the King, the Profession, Canadian Industries, the Faculty of Applied Science, and Kindred Societies. After that to the King, Mr. T. V. McCarthy presented the toast to The Profession. It was well responded to by Mr. David A. Molitor, C.E., whose presence at the dinner was most warmly delightful to those who had listened to his lecture to the Engineering Society on the previous day. Mr. Molitor's engineering experience was not confined to America, but it was partly gained in Germany, Austria, Switzerland, Italy and the Isthmus of Panama. In addition he occupied the chair in civil engineering for three years at Cornell University. His remarks in response to Mr. McCarthy's toast are gems of inestimable value to young engineers, and are, in part, as follows:—

The Engineering Profession

The broad definition of engineering is so comprehensive in its scope as to include practically all applications of the pure and natural sciences to the uses and convenience of man. This is necessarily an ideal conception and includes as many fields of activity as to preclude the possibility of accomplishment by any one individual or class of professional men.

Ideals are beautiful and stimulating, but can never be achieved, for no sooner do we carry an undertaking to successful completion than it becomes a thing of existence, and thereby ceases to be an ideal. Thus human ambition is constantly creating new ideals soaring above the realm of actual achievement.

What, then, are the prequisites of an engineer within the bounds of individual possibility? What are the useful tools, the command of which distinguishes an engineer from other individuals, professional or otherwise? What are the relations of the engineer to the general community? To answer these questions requires thought and experience.

When we further consider, that only four years of university work are allotted to the young man in which to acquire these prerequisites, then it becomes highly important to weigh most carefully the matter of efficiency in education.

It is possible for the average student to do a certain amount of work in a four years' course and do it well. An extraordinary student might accomplish more while one of inferior caliber could possibly cover the ground less thoroughly, or perhaps fail to attain the required standard.

Some technical schools have gone as far as to offer specialized courses leading to such degrees as mechanical, civil, hydraulic, sanitary, electrical, chemical engineer, all in the brief period of four years and with practically the same entrance requirements as for any baccalaureate degree.

J. E. Ritchie, who presided at the Annual Dinner

Practically the only difference in these several courses consists in the introduction of a few specialized subjects usually in the line of practical applications, at the expense of some of the fundamental sciences not directly bearing on such specialization, covering about the same sum total school hours for each degree.

If each young man could determine in advance precisely what his future field of activity is to be, such a procedure might be expedient, but few persons are so fortunate as to be able to read their horoscope with such accuracy.

There is still another very important factor not to be disregarded.

It is that young men are not allowed to do those things requiring highly specialized knowledge until they have first gained several years of experience along more general lines of engineering and have demonstrated their ability to grow and to become specialists by virtue of accumulated experience and judgment.

Why, then, seek to administer practical experience along special lines when school time is measured by a few hours and when the young graduate must work for many years before he can hope to apply such special knowledge which can only be satisfactorily acquired in actual practice.

In other words, if a man is going to practice engineering, he must first of all be an engineer, and finally becomes a specialist if his career leads in that direction.

But how is an engineer to become a specialist? By climbing the long ladder, experience; by studying; by availing himself of opportunities when they present themselves.

Considerations of this nature will suggest answers to the first and second questions. The prerequisites of an engineer are thorough knowledge of the fundamental sciences, mathematics, physics, mechanics, surveying, chemistry, astronomy, botany, bacteriology, geology, physiology, materials of construction, and a thorough course in English, including reading, writing, rhetoric and composition. These, also constitute his most useful tools by the aid of which he can continue his studies along any line of special science or engineering. In the course of acquiring this knowledge, the young man may have learned how to study and have the making of an investigator.

The man who has learned how to study, possesses the greatest asset which any university can bestow. To him, no field of science, no walk of life need offer an impassable entrance. This distinguishes the technically trained engineer from the one who grew up in practice alone; it also marks the man of broad training who can work out his own difficulties as against the man of specialized training who has nothing to fall back on except his specialty.

We come now to the question of standing of the profession in the community. How does engineering compare with the other learned professions? What have we engineers done to warrant the admiration and esteem of our fellow men? To answer this we must first see ourselves as others see us.

We have erected bridges and buildings, built tunnels, railways, waterways, and constructed machinery which has made the civilization of the day. To those who give us our just dues, we stand as masters of the industrial world, others liken us to locomotive or stationary engine men.

This is not surprising, for the advancement in civilization has not affected all men alike and the rank and file of our race may not be aware of who or what profession is responsible for the creation of the things they see.

The average engineer is a modest man. He rarely mentions his achievements; his name is often omitted from the works of his labors, and instead we see the names of politicians and money-men. It is a common occurrence to forget sending invitations to the engineering staff, when dedicatory celebrations are held at the successful completion of a great work. The engineers are the hired help, a sort of necessary evil.

Here we ourselves and the technical schools share the blame, We are no more than we make of ourselves, for the price we ask is all we can hope to get.

We have no particular standard of professional ethics; we do not look to our personal appearance in public as do members of the other learned professions and public men; and we are often afraid that our services are overpaid. While there are able and incompetent men practising the profession, there is no stamp of quality and competency by which we stand or fall individually, except in the case of colossal failure, and then the profession receives the blame usually because the money-man or politician hired a cheap engineer.

The time is ripe that our noble profession should receive the recognition which it justly deserves from the general community, and the first step in that direction must come from the combined efforts of the engineers and the universities who give them the stamp of recognition. It is a matter of mutual aid. The university must label its graduates accurately, and confer honors after graduation which are commensurate with their achievements. The alumni must do all in their power to further the interests of their alma mater.

A doctor of engineering will certainly enjoy the same distinction from the general public as is now accorded a doctor of law, medicine, or divinity. The university is the only tribunal to confer this honor on the leading members of our chosen profession and failure to do so means failure of recognition by the community.

From among his guests, Mr. Ritchie called upon Mr. J. L. Morris, the earliest graduate of the "School." It was especially pleasing to have him as one of us and his address was listened to with interest.

Mr. Morris found an incentive to say a few words to the students in Applied Science in response to the toast, "The Profession." As students and future graduates in Applied Science of the University of Toronto we have reason to feel proud of the course of instruction which you are receiving. For a member of years, engineers of all grades and branches have been coursing to us from Great Britain and the continent of Europe, some with creditable practice and others without.

Engineers whom we will call "hypochlorite engineers," because of their knowledge of the treatment of water for typhoid bacteria, are recommended to a municipality for this purpose, and often take upon themselves the construction of waterworks systems without having any previous experience and knowledge of this class of engineering. I am here reminded of an engineer, recommended by the Provincial Board of Health to report on the quality and treatment of water as a supply to prevent the recurrence of a typhoid epidemic, who agreed to engineer the construction of an intake pipe. It was a three-sixteenth inch plate eighteen inches in diameter, and his specifications actually called for rivets one inch in diameter spaced six inches apart for rivetting the three-sixteenth inch plate.

Notwithstanding what any foreign engineer may presume, I will say that you are receiving a training in engineering, suitable to the conditions of this country of ours, and there is no reason why any of you, when you go in to the practice of your profession, should submit to any outside engineering talent. The Canadian of to-day has institutions of learning preparing him to meet any others in professional competition.

Two other representatives of the earlier days of the School were also in attendance, Mr. J. W. Tyrrell, '83, and his brother, Mr. J. B. Tyrrell, M.A., '80. The latter is not a graduate in engineering, although his lectures were received in what was at that time the home of engineering, i. e., the north wing of the present building. Mr. Tyrrell is quite a School man, nevertheless, and his remarks were warmly received.

J. L. Morris, '81, the School's
earliest graduate.

"It gives me very great pleasure to be here this evening and to see around the tables so many students of a School which was founded while I was attending University of Toronto, and which I regard as the proper type of school, not only for this new country with its vast undeveloped resources, but for any country. From the time you enter, it furnishes you with a definite aim and purpose in all your studies and enables you to spend those splendid formative years, which are, perhaps, the most valuable years of your life, in acquiring suitable knowledge, and proper habits of thought, so that you may become efficient members of the community, prepared to perform your own individual duties, and also to contribute most fully and perfectly to the happiness and welfare of others. The courses in engineering prepare you not only to be good, helpful citizens, but also to be efficient and resourceful men capable of undertaking the development of enterprises of any magnitude, and of carrying these enterprises to successful issues with the least possible expenditure of energy and loss in friction, at the same time making you nobler and stronger men in consequence of your exertions and of your success.

"When I was an undergraduate, between the years 1876 and 1880, there were no engineering courses, or shall I call them purposeful courses, at the University of Toronto. If there had been I would certainly have taken one of them. As it was, the lectures which I attended during my last two years at college were given in the old engineering school which had just been built, and was being prepared for you, so that while I cannot claim to be a graduate in engineering, I can claim to have taken my college course at the same school from which you have graduated or will shortly graduate.

"Thirty-three years, which is the length of time since I graduated from the University, does not seem long when it has passed, but nevertheless as I look around this hall I see that there are only two of us here who were at the University at that time, Doctor W. H. Ellis as a professor, and I as a student. Since then many engineering courses have been established, but even yet the university authorities have not decided to grant a degree to the members of the profession which I am following, namely, that of geological engineer, though it will probably be recognized by them before many more years have passed.

"In their speeches, some of the students have shown that they have a high appreciation of the value of the education that has been taught to them, and that they look forward with interest and enthusiasm to the work which they hope to accomplish in after years. But I would like to urge on all here the necessity for a fuller appreciation of the work done by one another. As yet there is no large and full *esprit de corps* among Canadian engineers, and it is usually necessary for a Canadian to go outside of his own country to gain recognition for the work that he may have done in it. This is not as it should be. Canadians should support one another, and if they do so the world at large will also recognize their merit.

"Just one other point before I conclude. At the present time engineers of any kind have very little to say in the general management of Canadian national affairs. They may be in control of large industries, but they have not as a rule entered public life, and they have taken no part in the framing of the laws which govern and control these industries. This omission needs to be corrected. Engineers who know the resources and possibilities of our country are the men most capable of directing the legislation for the development and control of those resources, and I would urge you, as you value the welfare of your country, to do your utmost to see that proper, just, and intelligent laws are passed for its development, and if necessary, to lay party politics aside, and by offering a determined and undivided front in the elections, to make sure that some of your own engineers shall be elected to the House of Commons, and appointed to the Senate, in order that the nation may receive proper and competent advice not only in its ordinary every day legislation, but also in cases of emergency such as may arise at any moment. In connection with the great engineering enterprises on which the government of Canada is at present engaged, it would surely be wise for it to have some engineers, who understand the conditions limiting or controlling those enterprises among its members. As good citizens, the obligation devolves on you to arrange for a supply of such competent and high-minded engineers to undertake this public duty."

Mr. F. C. Mechin, '14, proposed "Canadian Industries," and the toast was jointly responded to by Sir Edmund Walker, chairman of the Board of Governors, University of Toronto, and president of the Canadian Bank of Commerce, and by Mr. J. S. McCannel, president and managing director of the Milton Pressed Brick Co. The remarks of the former were largely based upon the financial crisis with which the University was contending at the present time, expressing the hope that increased aid would shortly be forthcoming from the government, not only to assist in establishing courses to afford needed instruction in many channels of industry, but to prevent the otherwise necessary decrease in the present courses of instruction.

Mr. McCannel emphasized the need of technical training in the clay working industry. He expressed the hope of the Canadian Clay Products Manufacturers' Association that the University of Toronto would soon be in a position to train young men to scientifically cope with the problems met with in the manufacture of brick, tile and ceramic ware.

The toast, "The Faculty of Applied Science," was introduced by Mr. D. A. S. Mutch, '13, and President Falconer briefly responded. The president also dwelt upon the scarcity of funds which handicapped the University, and trusted to the early future to bring relief before drastic changes in the curriculum became unavoidable.

Dean Galbraith spoke for a short period upon the gradual development of the Faculty of Applied Science and Engineering into the institution which it is to-day. To those who listened to his remarks and searched among them for some admission of the many years of indefatigable exertion and monstrous responsibility to which he has been so consistently a devoted servant, in the interests of the engineering profession, no semblance of such accompanied his historical sketch.

Before the close of the event Mr. W. D. Black, '09, of Montreal, a past president of the Society, voiced the sentiments of the gathering in complimenting Mr. Ritchie and his executive upon the success of their dinner.

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EDITORIAL

FOREWORD REGARDING EMPLOYMENT

During the winter months we have had many enquiries for men, and some of them pertaining to positions of a very desirable nature. We have had few requests from graduates seeking to be put in touch with new and better fields. The inference is that of the two parties, the latter estimates the less the service of our employment bureau, although practically every application from them received satisfactory response. We make the assertion with the belief that not all our School men are employed just in the shadow of their ideals; that some are on the lookout for something better, not contented with the present state of things, considering all in all. It is they to whom our employment bureau might be of service during the months in which our undergraduates are in academic work, and out of the market for positions.

During the past year we have received nearly five hundred applications for technically trained men. Over half of them went a-begging. As in labor circles, the unskilled workman is in excess and the skilled in demand, so it is in the higher plane. In the profession of engineering the supply of efficiently capable young men is more in demand to-day than ever before in Canada, and to our Faculty of Applied Science and Engineering falls the heavy responsibility of properly equipping the men who yearly depart from it, with the proper knowledge and training. That it is doing its work well, is evidenced by the demand which the above figure indicates to have been created.

THE STUDENTS' SUMMER

The time is at hand when the employment bureau will be thoroughly taxed. It is the aim this year to make it more successful than ever, especially in the matter of speedily bringing together the two contracting parties. To the undergraduates who will be our chief applicants until well into the month of May, APPLIED SCIENCE would tender a few suggestions which, if followed, will be of assistance.

(1) Let your application be in writing. Nothing is to be gained by taking a whole morning to describe the kind of position you would like.

(2) Embody in your application a summary of all previous engineering or business experience.

(3) Mention the nature of employment preferred, and where. If a second or third choice be added, it may be advantageous.

That is not all. Co-operation is needed. If you are aware of a vacancy that is unsuited to your needs, put one of your classmates on the trail. Endeavour to select the best man for the work; or, bring it in and permit us to assist in having the position filled.

Graduates who require the services of others, or who are in a position to recommend others for vacancies on engineering work can be of invaluable assistance, and their favors in this direction will not pass unappreciated.

FOR CLASS EXECUTIVES

The re-union of class '09 shows what a very little effort (our apologies to the secretary) will do toward bringing together a class after nearly four years in pursuit of livelihood and laurels, and toward record breaking as well. Before its members experienced the stimulus of graduation they elected a president, a secretary and a cavalcade of councillors, appointing also a time when they would endeavor to re-unite. On the evening following the School dinner nearly sixty '09 men met at the St. Charles, and, under the direction of Mr. W. D. Black as toastmaster, enjoyed themselves with their companions of college years. Dean Galbraith and Dr. Ellis sent their regrets, being unable to attend owing to previous arrangements necessitating their appearance elsewhere, and the members of the class keenly felt their absence.

Professor Wright gave the banquet the required touch of academic tone, and during the course of the evening his remarks concerning the School and the class were most warmly received.

ENGINEERING ALUMNI ASSOCIATION

The Pittsburg Branch

The S.P.S. men in Pittsburg held an informal dinner on the evening of February 26th. M. L. Miller, '03, presented an interesting paper on the Panama Canal. Due to the removal from the city of Mr. G. Alison, the club's president, the election of officers took place at this meeting. The executive for the coming year consists of: President, H. O. Hill, '07; vice-president, E. B. Graham, '10; secretary-treasurer, M. L. Miller, '03, 206 Suburban Ave., Pittsburg.

The annual dinner of the branch is scheduled for April 2nd. Doubtless all University of Toronto men in that city and vicinity will communicate with the secretary and turn out to make the event the usual success that characterizes "School" dinners, no matter where held.

EXCURSIONS OF THE CHEMISTS

During the present session, a number of visits have been made by the chemists to manufacturing plants.

The industries which involve a knowledge of chemistry are very diverse, and demand a wide acquaintance with manufacturing processes—an acquaintance which is formed most rapidly and surely by a personal inspection of factories in operation.

A visit was paid on October 22nd, to Messrs. John Taylor & Co.'s soap factory on Front Street East. The manufacture of toilet and laundry soaps was followed through in detail, and the plant for the recovery of glycerine from the spent lyes was carefully inspected. The presentation to each man of a cake of soap or a tube of tooth paste is an indication of the courtesy and good will displayed by the officers of the company to the visitors.

On November 4th, an excursion was arranged to Messrs. Marlatt & Armstrong's tannery at Oakville. Mr. Kenneth Marlatt, one of our own graduates, received the party which numbered 20, and after discussing the main points in the tanning process, conducted the men over the factory. The splitting machine attracted a great deal of attention. This is a band knife—on the same principle as a band saw—and of about six feet effective length, by means of which a hide can be cut into as many layers as is desired. Our thanks are due to our hosts for kindly providing a 'bus to transport the party to and from the station, over some roads which need a highway engineer very badly.

A party of 18 left Toronto on November 16th, and spent the day at Berlin. Heuther's Brewery was first visited, and one of our own men, Mr. J. C. Heuther, was our guide. The various steps in the process were followed out, and the new cold storage and ice plant was inspected. After dinner, the party spent the afternoon at the Dominion Sugar Co.'s factory, where the campaign was in full swing. The process from the receipt of the beets to the shipping of the finished sugar was explained by the chemist in charge, and the mechanical equipment afforded excellent illustrations of the desiderata in chemical engineering.

A small party of senior men went up on November 30th to Longford to see the plant of the Standard Chemical Co. at that place. This is a wood distillation plant handling 48 cords of hardwood per day, and turning out wood alcohol, acetone and charcoal as products. The various types of large-scale stills and fractionating columns were studied with profit, and the partial construction of some new ovens permitted an inspection of their design and setting. The autone plant was also interesting, and it was learned that the entire output is marketed in England for the manufacture of smokeless powder.

On February 19th the works of the Gutta Percha and Rubber Mfg. Co. were visited, and a very profitable afternoon was spent in this large and very ably conducted establishment. The plant has recently been enlarged, and a new reinforced concrete building houses the automobile tire department, and the machinery for producing hose in continuous lengths. The washing, compounding, frictioning, cutting, boot and shoe making and hose manufacture were attractive and interesting, while one carried away an ineradicable impression of the mechanical methods of handling plastic materials. The well equipped laboratories were also very interesting, and two of our men, Messrs. Klotz and Eckert, are in charge of some of the work performed there.

During all the visits mentioned above, the parties were most kindly and hospitably entertained, and the chemists are very grateful to all those who have put themselves to so much trouble and inconvenience in arranging personally conducted tours through their factories.

THE REUNION OF '09

Class '09 held a reunion in Toronto during the second week in February. The School dinner, on the evening of February 13th, served as a formal opening for the convention, and a good representation of the class was in attendance.

On the following morning, at frequent intervals, groups of them passed through the buildings, and numerous old acquaintances were renewed. Changes in staff and equipment were noted. It surprised a good many to find the old red building still in commission, it having been pronounced unsuitable for further use, and a new one having been talked of, about the time the class were experiencing the sensations of graduating. The visitors recollected many incidents, not recorded in any minute book, that endear the old engineering building as the nucleus of the activities of the class during undergraduate days, and it will be cherished as a monument to such very heartily, although the baneful thought arises as to how some of the courses taught within, manage to flourish, practising in their own home so little of what is preached.

At noon on the fourteenth a luncheon was given at the Engineers' Club. Mr. Ross Workman, the secretary, was in charge of ceremonies, and presided over the smokes at a little business meeting afterwards. The discussion centered upon the practicability of a few minor changes that would add substance to the usefulness of the class organization. It was decided to compile a geographical map, illustrating the distribution of the class and to organize subsidiary committees in localities where a few could assemble frequently.

It was also decided to approach:

(1) Members of former years who ultimately became members of the class before graduation; and,

(2) Members of the class of '09 at its initial stage whose names appear in the graduating lists of more recent years; and,

(3) Members of the original class, who drifted into other walks of life prior to the final examinations.

Upon definite knowledge of the desire of each to retain connection with the class, the executive can outline its course. As soon as the membership of the class has been clearly defined, some important feature or movement is likely to be brought forward.

The afternoon was spent at one of the theatres, a good bill serving to dispel the atmosphere of business, in preparation for the evening ceremonies.

At the St. Charles, by eight o'clock, half a hundred chorused the "Che hee" and the "Toike Oike, "which were as ready as ever at the tip of the tongue, and half a hundred countenances beamed with satisfaction as "Dolly" Black accepted the premier position at the dinner table.

And the toastmaster was never in better form. Seated at his right and left hand were those whose attempts were futile to suppress the effervescence of long pent-up School-day demeanor, and our worthy chairman failed to display the mediative characteristics which we had expected to witness in a husband and father, and we cannot claim that he differed materially from Ross Harstone, Bill Tate, Dave Harvie, Eric Ryerson, or Sandy Sanderson, in the matter of being in best of form.

When the speeches were in order some well selected subjects brought forth sterling remarks about the School, the Class, and the event itself. Some whose oratory has continued to blossom every season since our knowledge of its quality was formed—Lew Rutledge, who fought a good fight for the electricals and mechanicals during our senior year; Bill Tate, the chaplain and advisor, and Professor Wright, whose interest in the class '09 is unparaleled among the potentates of the University, and whose presence was as highly appreciated as at any athletic, social or academic function in the olden time,—they were the proposers.

The Dean and Dr. Ellis, from whom a treat was anticipated by way of response to Tate's toast, "The School," were prevented from attending owing to meetings elsewhere requiring their participation. The menu prescribed that every man should make a two minute response to the toast, "Class '09," well proposed by Rutledge. In that time he was supposed to summarise the important events of his career as a man of the world. Early in the course of this phase of the proceedings the toastmaster and the secretary framed up an appeal that it was all a typographical error, and as the press reporters were one by one sliding into lethargy, the exploits of some half dozen sufficed as reply to the exhaustive demands of the proposer.

Professor Wright, in proposing a toast to "The Future," was conservative and reasonable in his prophecies, and the members of the class unanimously pronounced the climb as not too steep. He touched upon the acquisition of telegraphic, telephonic and illuminating facilities, mentioning as well the aerial, marine and rail transportation developments, as largely belonging to the past twenty years, and the advancement during the next two decades would be accelerated manifold by these one-time innovations. The next twenty years marked the lapse of time during which class '09 would give to the world its best service. Already members of the class had begun to win success and to court renown and others had chosen branches of the profession not conducive to precipitant distinction but worthy and pointing to substantial advancement before a great while.

Replying to the toast, H. Irwin referred largely to the pleasure and profit the class might derive if it adhered closely to the principles laid down at the first meeting it ever held as an undergraduate body. The voice of the meeting was, "Stick together"; and its final undergraduate meeting had come and gone with the same watchword unsullied and as potent as before. If the class upheld its ideals as a class, solid and self-sustaining, it would be a pleasure, in years to come, for its members to recollect the many reunions supplementing its journey through the halls of learning. It would not require too much sacrifice, or be too prodigious a task to compile a log, "The Last of the Noughty-Oughts-School" containing between its covers what of interest may be printed of the doings and sayings of the fellows, as chapter after chapter is breathed out. At any rate something more beckoning than a reunion every two or three years was necessary, and if the committee could select an acme of interest in which every member might indulge, it would form a bond in itself.

Letters were read by the toastmaster from absent members regretting deeply their inability to gratify their strong desire to be present—from Morton in Calgary, Sara in Winnipeg, Crosby in Vancouver, Danks in Sherbrooke, Woodley in Virginia, Palmer in Mexico, and others.

As a satisfactory close to such a successful event, W. D. Black was unanimously chosen president of the year until the next regular meeting three years hence, while G. R. Workman retains the office he has so admirably filled, as secretary to the Class.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the "A" "B" and "C" of the directory already published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

C (*Continued*)

Culbert, M. T., '02, deceased March 14th, 1911.

Cumming, J. D., '08, is at Copper Cliff, Ont., with the Canadian Copper Co.

Cumming, R., '02, is a member of the contracting firm of Miller, Cumming & Robertson, Toronto.

Cummins, O. F., '11, whose home is Chepstow, Ont., has no business address with us at present.

Cunerty, T. J., '11, is with the Westinghouse Electric and Manufacturing Co., East Pitsburg in the publicity dept.

Cunningham, C. H., '11, is designing engineer for Thor Iron Works, Toronto, of which firm he is a director.

Cunningham, R. H., '09 [illegible] Windsor, Ont. He is sales engineer for the Hoskin Manufacturing Co., Detroit.

Currie, W. M., '04, is a member of the staff of the Canada Steel Co. Hamilton.

Curzon, J. H., '11, is with the Canadian Pacific Railway at Moose Jaw, Sask., as chief draughtsman.

D

Dahl, A. D., '08, has Midland, Mich., for his address. He is chemist for the Dow Chemical Co.

Dallyn, F. A., '09, is with the Ontario Board of Health as consulting expert, in charge of the experimental station at Toronto.

D'Alton, F. K., '11, is taking an apprenticeship course with the Canadian General Electric Co., in the Peteroboro plant.

Daniels, W. N., '06, is in Philadelphia, Pa., in the employ of the John R. Wiggins Co.

Danks, F. A., '08, whose home is in Toronto, has no business address in our directory.

Danks, C. N., '09, is with the Jenckes Machine Co., Sherbrooke, Que., as engineer.

Dann, E. M., '09, is assistant engineer on hydrographic survey work in B. C. for the water power branch, Department of the Interior.

Darling, E. H., '98, is with the Hamilton Bridge Co., as engineer and manager of the east end plant of that firm in Hamilton, Ont.

Darroch, J., '08, has no address with us at present. When last heard from he was with the Autoparts Mfg. Co., Detroit, Mich., as draftsman.

Davis, J., '09, is sales engineer for the Canada Foundry Co. in connection with the Ottawa office.

Davis, H. W., '09, resides in Kingston, Ont., where he is in charge of the power department of the Davis Tanneries, Limited.

Davis, H. C., '09, until recently with the Hamilton Bridge Works, is at present in Bangalore, India.

Davis, R. S., '07, is manager of the Calgary office of the Canadian Westinghouse Co.

Davis, W. B., '11, is at Maple Creek, Sask., and is engaged in land surveying.

Davison, J. E., '00, is in the engineering department of the Canadian Northern Ry. Co. at Fort William, Ont.

Davison, A. E., '03, is with the Hydro Electric Power Commission, as engineer, with Toronto as headquarters.

Dawson, J. H., '09, is resident engineer for the T. C. R., at Cochrane, Ont. St. Catharines is his permanent address.

Deacon, T. R., '91, is president and general manager of the Manitoba Bridge and Iron Works. He is Mayor of Winnipeg, Man.

Dean, C. D., '10, has Sarnia, Ont., for his home address. We do not know his business address.

Death, N. P. F., '06, is a member of the firm of Death & Watson, electrical engineers and contractors, Toronto.

DeCew, J. A., '96, is in Montreal, Que., where he has a consulting practice in chemical engineering.

DeGuerre, F. C., '11, is in the engineering department of the British Columbia Electric Co., at Vancouver, B. C.

Delahaye, W. H., '09, is in the employ of the National Manufacturing Co., Brockville, Ont.

De Laporte, A.V.'10, is taking a post graduate course in chemical engineering, University of Toronto.

Depew, H. H., '04, was for some time superintendent of the Crow's Nest Pass Electric Light and Power Co., Fernie, B. C. We do not know if this is still correct.

Derham, W. P., '09, whose home is in Ottawa, is engaged in power house and switchboard in that city.

Dickson, G. W., '00, is with the Laurentide Co., Limited, Grand Mere, Quebec, paper manufacturers, as assistant superintendent of the ground wood mill.

Dickenson, E. D., '00, is with the General Electric Co., at Schenectady, N. Y.

Dill, C. W., '91, is general manager of the National Paving Co., Winnipeg, Man.

Dixon, H. A., '00, is at Resplendent, B. C., as district engineer for Mackenzie Mann & Co., on the C. N. P. Ry.

Dobbin, R. L., '10, is with Walter J. Francis & Co., on water power installation work at Moose Jaw, Sask.

Dobson, W. P., '10, is research fellow for the University of Toronto Engineering Alumni Association.

Dobie, J. S., '95, resides at Thessalon Ont., he is engaged in O. L. S. and D. L. S. work.

Dodds, W. A., '09, is chemical engineer for the Penman Littlehales Chemical Co., of Syracuse, N. Y.

Doorly, H. C., '08, is in St. Catharines, Ont., in the employ of that branch of the Jenckes Machine Co.

Douglas, R. H., '08, for some time since graduation, in the employ of the Department of Public Works, at Edmonton, has no address with us at present.

Douglas, W. E., '02, is secretary-treasurer of the McKnight Construction Co., Toronto.

Downing, F. H., '11, whose home is at Lucan, Ont., is with the Manitoba Bridge and Iron Works, Winnipeg,

Duff, A. R., '09, is chemist for the Dunlop Tire and Rubber Goods Co., Toronto, in the rubber department.

Duff, J. A., '90 (deceased), March 13th, 1902.

Duff, W. A., '01, is assistant bridge engineer for the Transcontinental Ry., Ottawa, Ont.

Duggan, G. H., '83, is vice-president and chief engineer of the Dominion Bridge Co., and chief engineer of the St. Lawrence Bridge Co., Montreal.

Dunbar, W. B., '11, whose home is in Dunbarton, Ont., is engaged in surveying practice in the West.

Duncan, J. M., '10, is marine engine draftsman with the Collingwood Shipbuilding Co., Collingwood.

Dundass, C. S., '06, is at Lachine, Que., with the Dominion Bridge Co., as draftsman.

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